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(19)

(54) ELASTIC MEMORY TUBING

(71) We, BRITISH INSULATED CALLENDAR'S CABLES LIMITED, a British Company of 21 Bloomsbury Street, London W.C.1. do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

This invention relates to the manufacture of elastic memory tubing of the kind having locked-in strains that can be released by heating to an appropriate temperature to cause the tubing to decrease its diameter.

It is known that tubing of this kind can be made from polyvinylchloride (PVC) compositions by extruding them into tubular form and whilst the extruding tube is at an appropriate temperature expanding it by a fluid pressure differential and chilling it in the expanded state.

In the case of PVC compositions containing no or only a small amount of plasticiser, this process has been operated on a continuous basis by continuously passing the extruded tube immediately it has been cooled to the appropriate temperature through a seal into a low-pressure chamber in which the expansion takes place, but it has hitherto not been found practicable to operate such a continuous process with PVC compositions containing a high proportion of plasticiser, (the term "plasticisers" as used herein including extenders in admixture with plasticisers).

In accordance with the present invention, a continuous method of making elastic-memory tubing from a plasticised PVC-based composition having a BS softness in the range 10 to 80 according to B.S.2782: 1965 part 3 method 307 comprises the steps of:

(1) extruding the said composition at a temperature at which it deforms wholly or predominately by plastic flow to form a tube

(2) cooling the said extruded tube to a temperature in the range that is above the softening point of the said composition but such that it deforms predominately elastically and coating the outside of the tube with a fluent lubricant which under the conditions obtaining wets the surface of the tube but does not dissolve into it or have any delerious effect upon it

(3) whilst the temperature of the tube is in the said range passing the tube through a closely-fitting sealing die into a chamber comprising a tubular portion, through which the tube passes, having an internal diameter greater than the external diameter of the tube

(4) applying suction to the said chamber to establish across the wall of the tube a pressure differential sufficient to distend the tube sensibly into contact with the said tubular portion of the chamber, and

(5) causing or permitting the tube to cool within said tubular portion to a temperature below its softening temperature.

By a fluent lubricant is meant a lubricant that is either a liquid or a solid material suspended in a liquid. The preferred lubricants are liquids, and especially a silicone oil such as that sold under the trademark "I.C.I." as "I.C.I. Silicone Oil F111/100"; the commonly available petroleum-derived liquid synthetic detergents can also be used. As an example of a lubricant which is a solid suspended in a liquid is mentioned a suspension of PTFE in silicone oil. It may be desirable to remove the lubricant, e.g. by washing in the case of a detergent, when the tubing is otherwise completed.

Preferably suction is applied to the expansion chamber at a number of places spaced along the tubular portion thereof and preferably at each position suction ports are distributed evenly about the circumference.

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In order to facilitate the extrusion step, a pressure slightly above atmospheric is preferably maintained within the tube throughout.

Typical PVC compositions that may be used in the invention are those containing 30-100 parts by weight of an ester-type plasticiser per hundred parts of resin.

The accompanying drawings show by way of example apparatus suitable for use in the method in accordance with the invention. In the drawings, *Figure 1* is a diagrame of the complete apparatus and *Figure 2* is an enlarged view of a portion of the apparatus.

The PVC compound, which may have, for example, the composition:

Polyvinylchloride	100 parts	by weight
Dibasic lead phthalate (stabiliser)	8 parts	
Di (tridecyl) phthalate (plasticiser)	50 parts	
(which may contain the usual antioxidant)		

is extruded in a conventional cross-head extruder with a pressure of about 27.5 kN/m² (gauge) applied to the core tube 2 to form a tube 3 having an external diameter of 9.0 mm and a wall thickness of 0.75 mm. The tube, which has a temperature of about 150-165°C as it emerges from the extrusion die, is cooled e.g. using one or more air jets 4 to about 90/110°C and is then lubricated by a drip feed 5 of I.C.I. silicone oil F111/100. The lubricated tube immediately passes (see also figure 2) through a sealing die 6 made of steel and having a diameter of 8 mm into a tubular expansion chamber 7, which is 300 mm long and 15.8 mm in diameter and which is cooled by water or other fluid circulated through a surrounding jacket 8. The expansion chamber is evacuated to 34.5 to 83 kN/m² (below atmospheric) through ports 9 and ducts 10, and the tubing emerges from the vacuum chamber through a further sealing die 11 having an external diameter of about 13.5 mm (some 15% less than the diameter of the expansion chamber) and at a temperature of about 25°C. The completed tubing is advanced by a belt grip traction device 12 to a take-up 13. The line speed may be about 3m/s measured at the take-up.

Upon re-heating above the softening point, the tubing will recover to an external diameter not less than about 10.4 mm. (15% greater than the diameter as initially extruded).

In starting up the line the unexpanded, extruded pvc tube is passed through the cooling device and vacuum chamber and on to the take-up arrangement. The take-up arrangement is then momentarily stopped, and a rubber 'bung' or stopper is placed in the outlet through which the tube leaves the vacuum chamber and vacuum is then applied. Once the tube has expanded sufficietly to seal the vacuum tube, the take up arrangement can be started and adjusted to a satisfactory speed.

The air jet or jets referred to as a possible means of cooling the extruded tube may be transverse to the tube axis or substantially parallel to it: in the latter case an annular nozzle through which the tube passes has been found convenient. As an alternative to air-cooling, a fluid cooling bath may be used but the coolant should be, or at least should be compatible with, the necessary fluid lubricant. Although the apparatus is shown by way of example with the axis of the tube horizontal, it could equally well be arranged vertically.

WHAT WE CLAIM IS:—

1. A continuous method of making elastic memory tubing from a plasticised PVC-based composition having a BS softness in the range 10 to 80 according to B.S. 2782: 1965 part 3 method 307 comprising the steps of

(1) extruding the said composition at a temperature at which is deforms wholly or predominately by plastic flow to form a tube

(2) cooling the said extruded tube to a temperature in the range that is above the softening point of the said composition but such that it deforms predominately elastically and coating the outside of the tube with a fluent lubricant (as defined) which under the conditions obtaining wets the surface of the tube but does not dissolve into it or have any deleterious effect upon it

(3) whilst the temperature of the tube is in the said range passing the tube through a closely-fitting sealing die into a chamber comprising a tubular portion, through which the tube passes, having an internal diameter greater than the external diameter of the tube

(4) applying suction to the said chamber to establish across the wall of the tube a pressure differential sufficient to distend the tube sensibly into contact with the said tubular portion of the chamber, and

(5) causing or permitting the tube to cool within said tubular portion to a temperature below its softening temperature.

2. A continuous method of making elastic memory tubing from a plasticised PVC-based composition having a BS softness in the range 10 to 80 according to B.S.2782: 1965 part 3 method 307 comprising the steps of

(1) extruding the said composition at a

temperature at which it deforms wholly or predominantly by plastic flow to form a tube

(2) cooling the said extruded tube to a temperature in the range that is above the softening point of the said composition but such that it deforms predominately elastically and coating the outside of the tube with a liquid lubricant which under the conditions obtaining wets the surface of the tube but does not dissolve into it or have any deleterious effect upon it

(3) whilst the temperature of the tube is in the said range passing the tube through a closely-fitting sealing die into a chamber comprising a tubular portion, through which the tube passes, having an internal diameter greater than the external diameter of the tube

(4) applying suction to the said chamber to establish across the wall of the tube a pressure differential sufficient to distend the tube sensibly into contact with the said tubular portion of the chamber, and

(5) causing or permitting the tube to cool within said tubular portion to a temperature below its softening temperature.

3. A method as claimed in Claim 2 in which the said lubricant is a silicone oil.

4. A method as claimed in Claim 2 in which the said lubricant is a petroleum derived liquid synthetic detergent.

5. A method as claimed in Claim 4 comprising washing the otherwise-completed tube to remove the said detergent.

6. A method as claimed in any preceding claim comprising maintaining within the said tube throughout the steps defined a pressure slightly above atmospheric.

7. A method as claimed in any one of the preceding claims in which the composition specified in step (1) of Claim 1 or Claim 2 contains 30-100 parts by weight of an ester-type plasticiser per hundred parts of resin.

8. A method as claimed in Claim 7 wherein the said composition comprises 100 parts polyvinylchloride, 8 parts dibasic lead phthalate, and 50 parts di(tridecyl) phthalate.

9. A continuous method of making elastic memory tubing of a soft plasticised polyvinylchloride composition substantially as hereinbefore described with reference to the accompanying drawings.

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1380397 COMPLETE SPECIFICATION
2 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheet 1

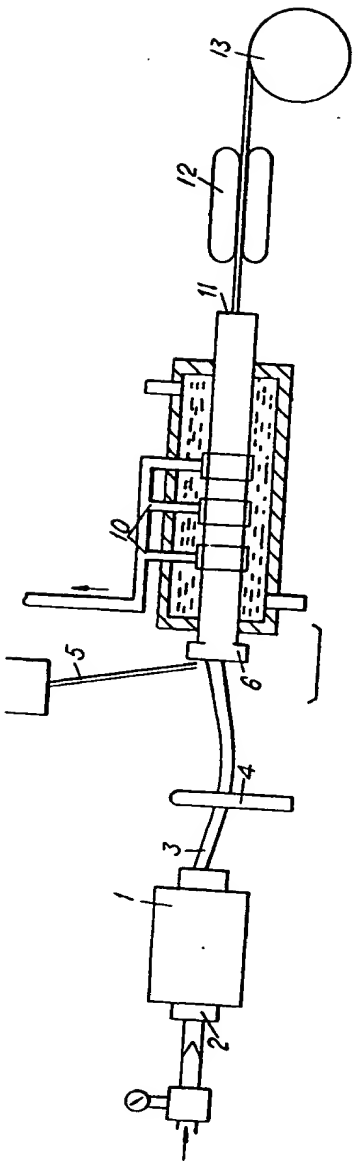

Fig.1.

1380397 COMPLETE SPECIFICATION
2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 2

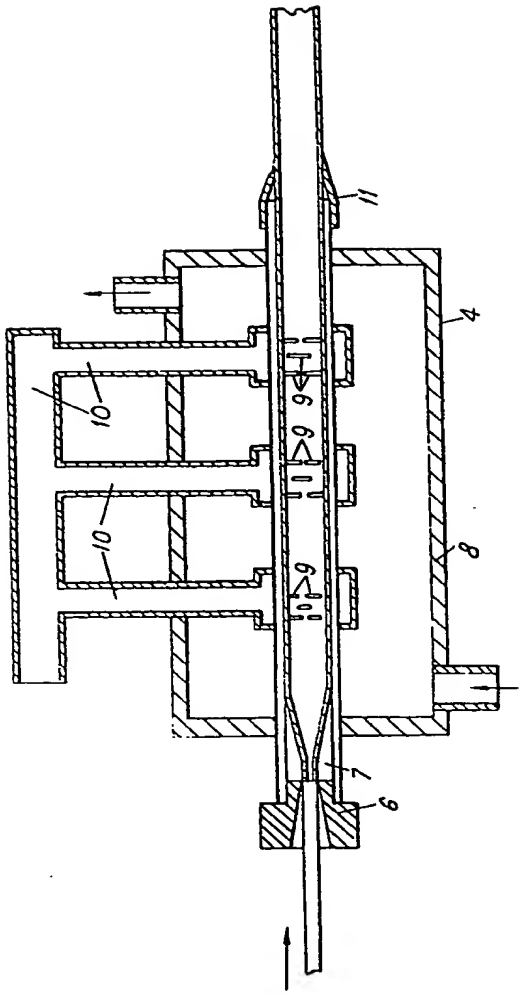

Fig. 2.